PATENT ABSTRACTS OF JAPAN

(11)Publication number : **07-326490**
(43)Date of publication of application : **12.12.1995**

(51)Int.CI. H05H 1/00

(21)Application number : **06-140756**
(22)Date of filing : **31.05.1994**

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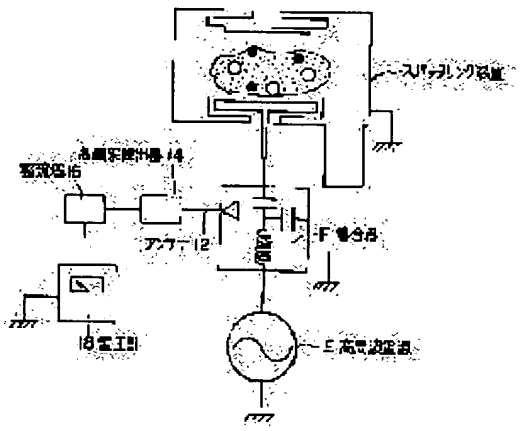
(54) DISCHARGE DETECTOR

(57)Abstract:
PURPOSE: To provide a highly reliable discharge detector that utilizes a new means different from conventional means of detecting plasma emission or the reflected waves of high-frequency inputs, etc.
CONSTITUTION: This discharge detector 10 has an antenna 12 for collecting high-frequency signals from a high-frequency power line through which discharging high-frequency power is supplied to a sputtering device or the like; a higher harmonic detecting portion 14 for detecting higher harmonics from the high-frequency signals collected; a rectifying portion 16 for rectifying the higher harmonics extracted; and a voltmeter 18 for measuring the voltage of a DC signal obtained through rectification by the rectifying portion 16. The discharge detector, utilizing the distortion of the input waveform of the high-frequency power due to the higher harmonics during discharging, extracts the higher harmonics component and converts it into the DC signal through rectification in order to enhance the accuracy of detection, and the voltage of the DC signal is measured by the voltmeter. When the measured voltage value of the DC signal is higher than a predetermined value, the detector indicates that a discharge has been started and is taking place, while when the voltage value is lower than the predetermined value the device indicates that the discharge is not started.



LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

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* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] A discharge detection machine characterized by having the collection section which collects RF signals from an RF generator line which supplies high-frequency power for discharge to equipment made to generate glow discharge, the 1st detecting element which detects a higher harmonic from collected RF signals, the rectification section which rectifies a higher harmonic, and the 2nd detecting element which detects a direct current signal rectified and acquired.
[Claim 2] A discharge detection machine according to claim 1 characterized by being the antenna with which said collection section was isolated and was prepared along said RF generator line.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the discharge detection machine which can detect a glow discharge phenomenon certainly further about the discharge detection machine which detects generating of a glow discharge phenomenon, without receiving the effect of disturbance in details.
[0002]
[Description of the Prior Art] In the manufacturing process of a semiconductor device, the equipment which performs various processings or processings variously using the plasma in

which induction is carried out by a discharge phenomenon, especially glow discharge is various, and is used. For example, a sputtering system, plasma-CVD equipment, a reactive ion etching system (an RIE system, plasma etching system), etc. can be mentioned as the example. since these equipments are constituted as automated possible equipment of consecutive processing thru/or continuation processing, it is important for them that the plasma is stabilized and is continuing within these plasma utilization equipment (the equipment which processes a processed material or processes it into a workpiece using the plasma, and the following -- the same). Therefore, in order to operate these equipments efficiently, the plasma occurs by discharge and it is necessary in the plasma being stabilized and continuing to be certainly detectable.

[0003] The plasma which the plasma means the condition of positive [which exercises freely], and the matter which a negative charged particle lives together and has become electrical neutrality, and is used by manufacture of a semiconductor device is discharge gas plasma in which was made to generate glow discharge, introducing inert gas and reactant gas in the chamber which carries out vacuum attraction and is in a fixed reduced pressure condition, and induction was carried out by it into the chamber. The plasma is generated using the ionization by collision of the electron and gas molecule which were accelerated by the electric field by the direct current voltage impressed to inter-electrode [which was prepared in the chamber], high-frequency voltage, or microwave. In the plasma, the neutral active species produced by dissociation of the atom of an excitation state besides ion and an electron, a molecule, or a molecule exists. Moreover, luminescence of an atomic proper arises in the process (relaxation) in which the excited atom and a molecule return to a ground state.

[0004] By the way, the following two means are used for detection of the conventional plasma. The one method is a method of detecting generating of the plasma, by detecting the light produced according to the luminous phenomenon of the plasma mentioned above. Other methods are methods applied to the equipment of the format of inputting and carrying out glow discharge of the high-frequency power, and generating the plasma by that cause. It is the method of detecting the reflected wave of the input RF generated by the mismatch, and detecting generating of the plasma. Although the equipment which inputs dozens of MHz high-frequency power, is made to generate electric field, is made to accelerate an electron by the electric field, and is made to generate the plasma is used abundantly in the manufacturing process of a semiconductor device, if high-frequency power is inputted, a reflected wave will occur by the mismatch. Then, usually an adjustment machine is formed, adjustment is taken and the reflected wave accompanying the input of high-frequency power is made small. Then, when high-frequency power energizes and the plasma occurs, it is equipment which detects the magnitude of a reflected wave and detects generating of the plasma by that cause using the phenomenon said that a reflected wave becomes small.

[0005]

[Problem(s) to be Solved by the Invention] However, although the sensing equipment for sensing atomic luminescence is required of the 1st above-mentioned method, it has the problem referred to as known sensing equipment being dramatically expensive and being unable to miniaturize it moreover. Moreover, there is also constraint of the aperture which a beam of light penetrates being prepared in plasma utilization equipment, or having to establish the

electric shielding means in which the surrounding extraneous light of plasma utilization equipment is made not to carry out incidence to sensing equipment. Furthermore, under today's condition of the occupancy floor space of plasma utilization equipment and occupied volume being reduced, and reducing the construction cost of a building, what is referred to as being unable to miniaturize sensing equipment also has the problem referred to as becoming the failure of construction cost reduction.

[0006] Since 2nd means to measure a reflected wave and to detect generating of the plasma on the other hand is measuring the magnitude of a reflected wave using the adjustment machine which is attached to plasma utilization equipment and has been formed, it can constitute a plasma detection means simply and economically, and also has the advantage referred to as being able to miniaturize moreover. However, actually, for various reasons, even if the plasma has not occurred, a reflected wave may become small enough. Even if this, i.e., the plasma, has not occurred actually, it will mean that it may take for the plasma having occurred, a nonconformity plasma treatment product will be discovered in the examination of products after passing through the process of after [termination of the process using the plasma concerned], or after that some, and the abnormal condition of the plasma will be recognized for the first time. Moreover, if such misconception is left and it continues operating, the RF generator for glow discharge will generate heat or break down. Thus, when using the unreliable conventional reflected wave detection type discharge detection machine, improvement in the product yield in plasma utilization equipment was difficult, and failure of the RF generator for glow discharge also had it. [much]

[0007] Then, an example is taken by the problem of the conventional discharge detection machine, and the object of this invention is offering a discharge detection machine with the high reliability using a new detection means the conventional means', such as luminescence of the plasma or detection of the reflected wave of a RF input, differing.

[0008]

[Means for Solving the Problem and its Function] this invention person paid his attention to the following thing in process of research. Although high-frequency power is drawing a beautiful wave as shown in drawing 3 (a) in plasma utilization equipment which it is making generate plasma with high-frequency power when a glow discharge phenomenon is not started While a glow discharge phenomenon is started and an input of high-frequency power is maintained A RF wave of high-frequency power is saying that it is the wave distorted greatly as shown in drawing 3 (b), and such a wave-like distortion is generated when a signal's of frequency of the integral multiple, i.e., a higher harmonic's, was overlapped on an original RF (fundamental wave). And this invention person came to complete this invention based on this knowledge.

[0009] The discharge detection machine which applies to this invention in order to attain the above-mentioned object is characterized by to have the collection section which collects RF signals from an RF generator line which supplies high-frequency power for discharge to equipment made to generate glow discharge, the 1st detecting element which detect a higher harmonic from the collected RF signals, the rectification section which rectify a higher harmonic, and the 2nd detecting element which detect the direct current signal which rectified and acquired. The 1st detecting element says a circuit which detects a higher harmonic from a RF signal, for example, a high-pass filter circuit which extracts a higher harmonic from a RF

signal. The rectification section is diode, and it is prepared in order to raise detection precision of a higher harmonic. The 2nd detecting element is a circuit which detects a direct current signal, for example, says a voltmeter or an ammeter. A discharge detection machine concerning this invention can be used for equipment which inputs high-frequency power and is made to generate a discharge phenomenon, and can be used suitable for plasma utilization equipment made to generate plasma especially by glow discharge.

[0010] In the suitable embodiment of this invention, it is characterized by being the antenna with which the collection section was isolated and was prepared along said RF generator line. Although direct continuation of the collection section of a RF signal can also be carried out to an RF generator line, since voltage is high and dangerous, its creeping method of adjustment using an antenna is more desirable.

[0011]

[Example] Hereafter, with reference to an accompanying drawing, this invention is explained more to details based on an example. The mimetic diagram and drawing 2 which show the configuration of one example of the discharge detection machine which drawing 1 requires for this invention are the circuit diagram of the RF detector of a discharge detection machine, and a rectifier circuit. Drawing 4 is the mimetic diagram showing the configuration of the sputtering system which attached the discharge detection machine concerning this invention. The sputtering system consists of a substrate electrode B prepared in the up space of Chamber A and Chamber A which generates the plasma, and a target C arranged at the lower part of Chamber A, as shown in drawing 4 . It connects with the evacuation pump (not shown) and Chamber A is maintained by the reduced pressure condition. The substrate electrode B constitutes an anode plate, and is usually grounded, Substrate D is fixed on the substrate electrode B, and a desired film is formed. Target C is formed with the same material as the metal membrane which wants to form membranes on Substrate D, constitutes cathode, and is connected to RF generator E for glow discharge. Moreover, in order to take adjustment with a load and a power supply, the adjustment machine F is formed in the RF generator line.

[0012] If Ar gas is enclosed with the sputtering system shown in drawing 4 and the high-frequency power for glow discharge is inputted into Target C, Plasma G will occur. Consequently, Ar gas is Ar+. It ionizes in ion, an electron, and neutral Ar atom, and is Ar+. It collides with the target C with which ion constitutes cathode, and a target atom is made to emit from Target C. A target atom flies toward the substrate electrode B, collides with Substrate D, is deposited there, and forms a metal membrane. Therefore, in order to form a good metal membrane with a sputtering system, it is a requirement that the plasma is maintained by stability by positive initiation and its continuation of a glow discharge phenomenon. Therefore, as shown in drawing 1 , the discharge detection machine concerning this invention was attached to the sputtering system, and initiation and its continuation of a glow discharge phenomenon are detected.

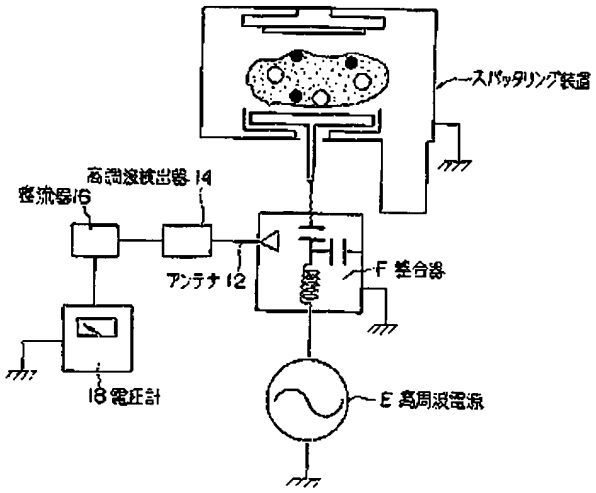
[0013] The antenna 12 with which the discharge detection machine 10 of this example collects RF signals from the RF generator line which supplies the high-frequency power for discharge to a sputtering system as shown in drawing 1 , It has the voltmeter 18 which measures the voltage of the direct current signal which it was rectified in the RF detecting element 14 which detects a higher harmonic, the rectification section 16 which follows the RF detecting element

14 and rectifies the extracted higher harmonic, and the rectification section 16, and was acquired from the RF signal which followed the antenna 12 and were collected.
[0014] An antenna 12 constitutes the RF collection section which consists of lead wire, such as copper wire which was isolated on the RF generator line and was mostly stretched by parallel, and inputs it into the RF detecting element 14 by making into a RF signal high-frequency power guided to this. It has the higher-harmonic detector which consists of a high-pass filter circuit, and separates into the fundamental wave and higher harmonic of a RF, and the RF detecting element 14 extracts only a higher harmonic, and inputs it into the rectification section 16. The rectification section 16 is equipped with a rectifier circuit, rectifies the inputted higher harmonic, and makes it a direct current signal.
[0015] The RF detector of the RF detecting element 14 and the rectifier circuit of the rectification section 16 consist of this examples, as shown in drawing 2 . A circuit equips an input side with input terminal TI+ and earth terminal TI-, and equips an output side with output terminal TO+ and earth terminal TO-, respectively, and the touch-down line is connected between earth terminal TI- and TO-. A RF signal is inputted between input terminal TI+ and earth terminal TI-. In input terminal TI+, they are a capacitor C1 and C2. And diode D1 of the forward direction It connects with the serial one by one. Capacitor C1 C2 Between inlet connection and a touch-down line, it is a coil L1. And variable resistor RV It connects with juxtaposition and is a capacitor C2. Diode D1 Between the inlet connection of an anode, and a touch-down line, it is a coil L2. It connects. As mentioned above, a capacitor C1, C2 and a coil L1, and L2 And variable resistor RV The becoming circuit constitutes a high-pass filter circuit, extracts harmonic content from a RF signal, and is a variable resistor RV. Gain is adjusted.
[0016] Diode D1 The extracted harmonic content is rectified. Diode D1 A cathode is the capacitor C3 by which the end was connected to the touch-down line. Coil L3 by which the other end and an end were connected to output terminal TO+ It connects with the other end. Between output terminal TO+ and a touch-down line, they are a capacitor C4 and a coil L4. Capacitor C5 A series circuit and diode D2 of hard flow It connects. Thus, the constituted circuit is a smoothing circuit which graduates the direct current signal which rectified and acquired the higher harmonic, and the graduated direct current signal is outputted from output terminal TO+.
[0017] By the above configuration, in order that the discharge detection machine 10 of this example may extract the harmonic content using the input wave of the high-frequency power at the time of glow discharge being distorted by the higher harmonic and may raise detection precision, it rectifies, and it is changed into a direct current signal, and the voltage of the direct current signal is measured with a voltmeter 18. Glow discharge being started when the voltage measurement value of a direct current signal is higher than a predetermined value, and continuing is shown, and in being lower than a predetermined value, it shows that glow discharge is not started. Thereby, the discharge detection machine 10 of this example can detect generating of a glow discharge phenomenon certainly, and moreover, since each component of the discharge detection machine 10 is compact, it can miniaturize it. Moreover, since the magnitude of a higher harmonic becomes one index which shows the quality of adjustment, an adjustment condition is also controllable by measuring the magnitude of a

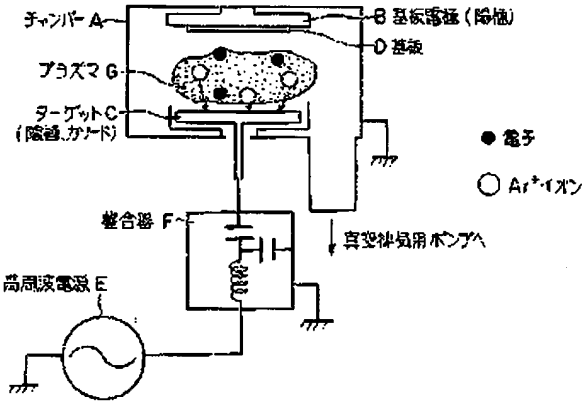
higher harmonic, i.e., the voltage of a direct current signal rectified and obtained.
[0018]
[Effect of the Invention] The collection section which collects RF signals from an RF generator line according to the discharge detection machine concerning this invention, and the 1st detecting element which detects a higher harmonic from the collected RF signals, Initiation and its continuation of glow discharge are certainly detectable by having the rectification section which rectifies a higher harmonic, and the 2nd detecting element which detects the direct current signal rectified and acquired, extracting the higher harmonic generated in initiation and coincidence of glow discharge, rectifying, and detecting the acquired direct current signal. Moreover, since each component of a discharge detection machine is compact, it can miniaturize. If this discharge detection machine is used for plasma utilization equipment, a profit which is listed to a degree can be obtained. since generating of the plasma and continuation can be checked by detecting generating of a glow discharge phenomenon, and continuation in the 1st -- the opportunity side of plasma utilization equipment -- an operator -- generating and its stable continuation of the plasma -- each time -- it is not necessary to check -- becoming . Therefore, automation of plasma utilization equipment is promoted. Since poor generating of the plasma, dissipation, etc. are promptly detectable, by suspending plasma utilization equipment immediately, generating of a defective can be controlled in the 2nd and the product yield can be raised in it. Furthermore, the plasma cannot occur within plasma utilization equipment, or alarm can be sent at the time of that abnormal occurrence as the plasma was extinguished, and it can warn an operator of that. By this, since a cure can be taken promptly, the product yield improves further. Moreover, pyrexia of the RF generator for glow discharge etc. can be prevented, and safety can be raised.

[Translation done.]

【図1】


スパッタリング装置
高周波検出器 14
整流器16
アンテナ 12
F 整合器
18 電圧計
E 高周波電源

【図4】


チャンバー A
B 基板電極（陰極）
D 基板
プラズマ G
ターゲット C
（陰極、カソード）
● 電子
○ Ar+イオン
整合器 F
真空排気用ポンプへ
高周波電源 E

ラインに接続されたコンデンサC₂の他端と、一端が出力端子T₀₊に接続されたコイルL₂の他端とに接続されている。出力端子T₀₊と接地ラインとの間にはコンデンサC₃、コイルL₃とコンデンサC₅の直列回路、及び逆方向のダイオードD₂が接続されている。このように構成された回路は、高調波を整流して得た直流信号を平滑化する平滑回路で、平滑化された直流信号は、出力端子T₀₊から出力される。

【００１７】以上の構成により、本実施例の放電検出機１０は、グロー放電時の高周波電力の入力波形が高調波により歪んでいることを利用して、その高調波成分を抽出し、検出精度を向上させるために整流して直流信号に変え、その直流信号の電圧を電圧計１８により計測する。直流信号の電圧計測値が所定値より高い場合にはグロー放電が開始され、かつ持続していることを示し、所定値より低い場合にはグロー放電が開始されていないことを示す。これにより、本実施例の放電検出機１０は、確実にグロー放電現象の発生を検出することができ、しかも放電検出機１０の各構成要素がコンパクトであるから、小型化できる。また、高調波の大きさは整合の良否を示す一つの指標となるので、高調波の大きさ、即ち整流して得た直流信号の電圧を測定することにより、整合状態を制御することもできる。

【００１８】

【発明の効果】本発明に係る放電検出機によれば、高周波電源ラインから高周波信号を収集する収集部、収集した高周波信号から高調波を検出する第１検出部と、高調波を整流する整流部と、整流して得た直流信号を検出する第２検出部とを備え、グロー放電の開始と同時に発生する高調波を抽出、整流し、得た直流信号を検出することにより、グロー放電の開始及びその持続を確実に検出することができる。また、放電検出機の各構成要素がコンパクトであるから、小型化できる。本放電検出機をプ＊ラズマ利用装置に使用すれば、次に挙げるような利益を得ることができる。第１には、グロー放電現象の発生、持続を検出することにより、プラズマの発生、持続を確認できるので、プラズマ利用装置の機側でオペレータがプラズマの発生及びその安定的な持続を都度確認する必要がなくなる。よって、プラズマ利用装置の自動化が促進される。第２には、プラズマの発生不良、消滅等を速やかに検知することができるので、プラズマ利用装置を即座に停止することにより、不良品の発生を抑制して製品歩留りを向上させることができる。更には、プラズマ利用装置内でプラズマが発生しないとか或いはプラズマが消滅したとかの異常発生時には、アラームを発信してその旨をオペレータに警告することができる。これによって、速やかに対策を講じることができるので、一層、製品歩留りが向上する。また、グロー放電用高周波電源の発熱等を防止し、安全性を向上させることができる。

【図面の簡単な説明】

【図１】本発明に係る放電検出機の一実施例の構成を示す模式図である。

【図２】放電検出機の高調波検出回路及び整流回路の一例の回路図である。

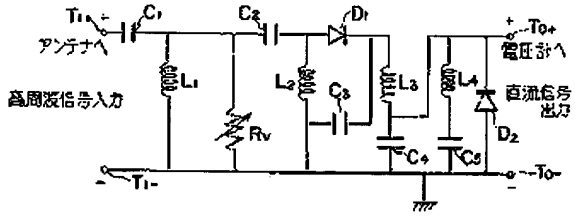
【図３】図３（ａ）は放電のないときの入力高周波の波形を示す波形図、図３（ｂ）は放電している時の入力高周波の波形を示す波形図である。

【図４】本発明に係る放電検出機を設置するスパッタリング装置の構成を示す模式図である。

【符号の説明】

１０　放電検出機
１２　アンテナ
１４　高周波検出部
１６　整流部
１８　電圧計

【図２】



【図３】